

# A LOWER CARBONIFEROUS CONODONT FAUNA FROM CHILLATON, SOUTHWEST DEVONSHIRE

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ABSTRACT. Siliceous shale in the Lower Carboniferous at Chillaton, Devonshire, has abundant moulds of conodonts. The relatively rare genus *Dollymae* is represented by the species *D. hassi*, which has previously been found only in the upper part of the German *anchoralis*-Zone. The presence of this form might seem to give a precise indication of the age of the Chillaton fauna. However, the three primary indices recommended for the *anchoralis*-Zone by Voges are missing. It is therefore necessary to take account of information from Texas and Belgium, where *Dollymae* species (although, so far, not *D. hassi*) are known to occur before the first appearance of *Scaliognathus anchoralis*. It emerges that the new fauna from Devonshire has much in common with what has been found in Texas, but rather less in common with what has been reported from Belgium. The Chillaton fauna is regarded, for the present, as being approximately of *anchoralis*-Zone age.

The systematic section deals principally with *Dollymae* and *Gnathodus*. Present information on the genus *Dollymae* is reviewed. Hass' and Voges' information is included, with a corrected rendering of assumptions on the orientation of this conodont. In *Gnathodus*, a wide variety of form is referred to *G. punctatus*. It is suggested that particular variants of *G. punctatus* might have been the sources from which particular species of *Dollymae* were derived.

LOWER Carboniferous conodont faunas attributable to the German *anchoralis*-Zone (Bischoff 1957; Voges 1959, 1960) have a wide distribution in Europe, North Africa, and North America.

The record runs from Austria (Flügel and Ziegler 1957; Schulze 1968) and Czechoslovakia (Zikmundová 1967; Friáková 1968; Conil, Dvořák and Freyer 1971) to North Africa (Remack-Petitot 1960), Spain (Ziegler 1959; Higgins, Wagner-Gentis and Wagner 1964; Budinger 1965; van Adrichem Boogaert 1967; Marks and Wensink 1970), Portugal (van den Boogard 1963), France (Remack-Petitot 1960; Pelhâte 1969), Belgium (Conil, Lys and Mauvier 1964; Conil, Austin, Lys and Rhodes 1969; Groessens 1971), England (Matthews 1961, 1969a, 1969b; Morris 1970) and Ireland (Hill 1971). In North America there are reports of *Scaliognathus anchoralis* from Missouri and Oklahoma (Branson and Mehl 1941), Missouri (Thompson 1967), Missouri and Arkansas (Thompson and Fellows 1970), Texas (Hass 1959) and New Mexico (Burton 1964).

Meischner (1971) has recently reviewed the succession of conodont faunas found in the Carboniferous of Germany. He has been able to confirm the essentials of Voges' reading of the early Carboniferous sequence of forms and he supplies numerous observations on *anchoralis*-Zone faunas. Meischner has found that the genus *Dollymae* is confined to an upper part of the *anchoralis*-Zone, as Voges (1959, table 1) and Böger (1962) had already indicated. This would seem immediately to provide a basis for dating a conodont fauna recently discovered in the Lower Carboniferous of the south-western part of Devonshire. The new fauna has *Dollymae* in association with abundant gnathodids, and includes a few representatives of the genus *Siphonodella* (*S. crenulata* and *S. obsoleta*). These last, according to the German evidence (Voges 1959 and Meischner 1971 rather than Böger 1962), range upward into the higher parts of the *anchoralis*-Zone.

## THE COMPOSITION OF THE CHILLATON CONODONT FAUNA

The conodonts were found (by E.B.S.) as moulds on fine, hard siliceous shale in Marlow's Quarry (SX 4349 8178), at Chillaton, which lies about 8 km north-west of Tavistock. Preservation and preparation are exactly as described in Matthews (1969a, 1969b). The forms identified (from latex pulls of the two surfaces produced by parting a single bedding-plane) are:

- Dollymae hassi* Voges.
- Gnathodus delicatus* Branson and Mehl.
- Gnathodus punctatus* (Cooper).
- Gnathodus semiglaber* Bischoff.
- Polygnathus communis communis* Branson and Mehl.
- Polygnathus communis carina* Hass.
- Pseudopolygnathus triangulus* Voges subsp. indet.
- Siphonodella cremulata* (Cooper).
- Siphonodella obsoleta* Hass.
- Spathognathodus* cf. *stabilis* (Branson and Mehl).
- Chitinophosphatic brachiopods.

Over 16,000 moulds (representing half that number of conodonts) are seen on approximately 800 cm<sup>2</sup> of rock surface. Over 80% of the total number of conodonts are bar types. They are omitted from the list above because they have no significance in an estimation of the age of the fauna. Their distribution on the rock-surface gives no direct suggestion of the presence of assemblages. A later communication will deal with the form-relationships and relative abundance of the bar-types available on this and other surfaces in the Chillaton siliceous shale.

German evidence, as mentioned above, would suggest that a fauna of this composition belongs in an upper part of the *anchoralis*-Zone. It is therefore surprising that *Scaliognathus anchoralis*, *Hindeodella segaformis* and *Doliognathus latus*, the three distinctive forms nominated by Voges as indices to the *anchoralis*-Zone, are not represented. Meischner (1971, p. 1176) offers one possible explanation of such a case. He remarks that in Germany a distinction can be made between basin-associated *anchoralis*-Zone faunas (with *S. anchoralis*, siphonodellids and polygnathids related to *P. inornatus*) and Schwelle-associated faunas (gnathodids very much dominant and *S. anchoralis* rare or even absent, in which case the attribution to the *anchoralis*-Zone may not be entirely straightforward). The Chillaton fauna, which has abundant gnathodids, few siphonodellids and no *Scaliognathus anchoralis* nor *Polygnathus inornatus*, shows some resemblance to those of Schwelle type, a suggestion which could draw support from work now in progress on the stratigraphy of the Tavistock-Launceston area. Work in progress in Germany should show whether *Dollymae* is consistently more abundant on Schwellen sites. If this proves to be so, the distinction Meischner makes could perhaps be restated as one in which the basinal faunas have a relatively high number of forms with restricted basal cavities (polygnathids, *Scaliognathus*) and the Schwellen faunas a greater proportion of forms with widely flared basal excavations (gnathodids, *Dollymae*).

While these matters are under investigation, it would be well to consider any alternative explanation of the absence of the three *anchoralis*-Zone indices from this fauna. It is, for example, necessary to note the fact that *Dollymae* (although not, as yet, any example of *D. hassi*) is known to occur in Texas (Hass 1959) and in Belgium

(Groessens 1971) before the first emergence of *S. anchoralis*. Both of these cases deserve to be examined here for any evidence of comparability with the Chillaton occurrence.

In the Chappel Limestone of Texas, Hass (1959; table 1, collections 9307, 15569, 15570, 15581, 9377) found *Dollymae sagittula* in his *Gnathodus punctatus* Zone. Forms such as *Scaliognathus anchoralis* and *Doliognathus excavatus* (which is close to *Doliognathus latus*—see Voges 1959, p. 275, and Thompson, 1967, p. 34), first appear in his *Bactrognathus communis* Zone above. Hass encountered some Devonian and even Ordovician forms in the Chappel Limestone. These obviously indicate reworking, and it has been suggested that the process of reworking might also have effected some rearrangement of the Mississippian conodonts present. Thompson and Fellows (1970, p. 60), who are of this opinion, mention the thinness of the Chappel Limestone, and suggest that deposition was slow and recycling of conodont material common. Hass's sampling, according to Thompson and Fellows, tended to lump together faunas which they themselves would claim to have separated by detailed sampling of sections elsewhere. Hass's (1959) paper provides for a response to these criticisms. First, it can be observed (e.g. in table 1 of Hass 1959) that Hass's samples were closely spaced, and that the collections he made from his samples show evidence of relatively coherent associations of forms: one notes, for example, the series of *G. punctatus* specimens, all from collection 9301, illustrated by Hass (1959, pl. 47, figs. 11–18). Or, taking the samples that produced *Dollymae sagittula*, one finds that its associates are present in fairly regular numerical proportions. Among these samples one finds cases (9037, 15569, and 15570) in which the number of pre-Chappel forms is quite small. Further, it would be reasonable to consider the fact that Lindström (1964, p. 97, reporting the work of A. J. Scott) was able to refer to meaningful gradations of form in conodonts recovered from a single sample collected in the (presumably) upper part of the Chappel Limestone. The view taken here is that although there is clear evidence that pre-Mississippian conodonts were reworked into the Chappel Limestone, there may not have been any considerable re-arrangement of the Mississippian conodonts themselves. Hass's *Gnathodus punctatus* Zone faunas compare well with what is found at Chillaton. Abundant *G. punctatus* and *G. delicatus* are common to the two cases (there are, however, some minor differences between the two sets of *G. punctatus*—see below). Both have siphonodellids and *P. communis carina*. The resemblance is close, and yet it is *Dollymae sagittula* that appears in Texas, and *D. hassi* in Devonshire.

The Belgian evidence which should be considered here comes from Groessens (1971) who has found yet another species of *Dollymae*, *D. bouckaerti* (a relatively simple form, which Groessens takes to be the same as Voges' *Dollymae* sp. B) in the late Tournaisian (Tn 3c). Immediately above, the conodonts of Groessens' *Scaliognathus anchoralis-Hindeodella segaformis* Assemblage Zone make their appearance. Groessens' first report of his findings (Groessens 1971) seems to offer little for comparison with the Chillaton evidence. *D. bouckaerti* and *D. hassi* are quite different. Groessens makes no mention of *G. punctatus*. Siphonodellids occur at Chillaton, but Groessens would regard these as having met extinction in Tn 3a of the Belgian succession. The Belgian pseudopolygnathids, which are different from those found at Chillaton, appear to have more in common with pseudopolygnathids found in the German *anchoralis*-Zone. The only distinctive form common to all these occurrences—Texas, Germany, Belgium, Devonshire—is *Polygnathus communis carina*.



There is one further record of *Dollymae* to be mentioned. Boyer, Krylatov, Le Fèvre and Stoppel (1968, fig. 8) show their sample SK 260+CE 154 to include *D. hassi* and *Protognathodus kockeli* as well as numerous other forms. They refer this fauna to a high *Gattendorfia*-Stage horizon. Obviously, this particular record requires re-examination.

Summarizing this discussion, one would say that until now *Dollymae hassi* has been encountered only in the late *anchoralis*-Zone of Germany (with the exception of the puzzling French case mentioned above). There are, however, records from Texas and from Belgium which show that other forms of *Dollymae* can occur before *S. anchoralis*. The Chillaton fauna has much in common with the Texas case, but a great deal less in common with what has been reported from Belgium. The age of the Chillaton fauna may be taken, for the present, to be approximately in the range of the German *anchoralis*-Zone. Future inquiries may hope to show whether different modes of the genus *Dollymae* could have been generated at slightly different times. Any such inquiry may derive some assistance from the review of the present state of information on the genus which is included below, and which corrects a conspicuous error that exists in much of the descriptive material so far published.

#### SYSTEMATIC NOTES

Numbers prefixed BU refer to the collections in the Geology Museum, University of Bristol. Each five-figure number identifies one surface of a rock specimen. Suffixes to a five-figure number locate particular moulds present on that surface. It will be understood that two different numbers, each with its suffix, may refer to two aspects of a single conodont. The illustrations show latex ('Revultex') pulls dusted with ammonium chloride. Deeper parts of the moulds (e.g. the crest of the blade in the mould of an oral surface) of these small fossils will often test the pull technique to its limits—any local incompleteness of particular specimens as seen in the illustrations should be assumed to be due to this cause rather than taken as evidence of abrasion of the conodont.

Complete counts of specimens are given only for *Dollymae*, *Siphonodella* and *Spathognathodus*. Total numbers of the other forms (gnathodids, polygnathids) will be supplied when the bar-type conodonts have been studied on this and other surfaces in the siliceous shale. Any count of individual *Gnathodus* 'species' will involve numerous decisions on the specific identity of the many 'transitional' forms available.

The synonymy lists carry some of the signs proposed by R. Richter (*Einführung in die zoologische Nomenklatur*, Kramer Verlag, Frankfurt-a-M. (2nd edition), 1948). These signs are intended to indicate the different levels of confidence with which an author might insert items in his synonymy lists. They are widely used in German language publications.

#### Genus DOLLYMAE Hass 1959

1959 *Dollymae* gen. nov. Hass, p. 394.

1959 *Dollymae* Hass; Voges, p. 275.

1964 *Dollymae* Hass; Lindström, p. 168.

*Remarks.* Finds of the genus *Dollymae* are recorded in papers by Hass (1959), Voges (1959), Böger (1962), Ziegler (1963), Krebs (1968), Boyer *et al.* (1968) and Groessens (1971). Groessens (1971) mentions that further discoveries have been made in Belgium and Ireland.

Hass's (1959) brief first description of the genus (restated in Hass 1962) is, apart from what appears in Lindström's book of 1964, the sole systematic statement on the genus in the English language. Voges (1959) made much fuller reference to *Dollymae*, and

brought three new forms, *Dollymae hassi*, *Dollymae* sp. A and *Dollymae* sp. B, to join *Dollymae sagittula*, the single species Hass had proposed. Böger (1962) would have established *Dollymae* sp. B of Voges as the species *Dollymae vogesi*; but, as Ziegler (1963) and Conil and Paproth (1968) have already pointed out, his *Dollymae vogesi* must be regarded as a nomen nudum. Groessens (1971) has now proposed that *Dollymae* sp. B of Voges be absorbed in his own *Dollymae bouckaerti*.

Scott, Ellison, Rexroad, and Ziegler (1962) have called attention to the fact that the conventions on the orientation of conodonts (especially the sense of the terms 'anterior' and 'posterior') employed by Hass differ from those used by the majority of conodont workers. Hass's system of orientation appears in his descriptive references (1959, 1962) to *Dollymae*. It is perhaps not widely realized that Voges (1959) followed the Hass scheme of orientation when referring to German occurrences of this genus (lapsing into 'normality' on one single occasion—Voges 1959, p. 275) although taking the more conventional course in all the rest of his systematic descriptions. One finds, therefore, that all of the descriptive references to the genus *Dollymae* in the present literature, with the exception of Lindström's (1964) brief note and Groessens's (1971) relatively brief description (in French) of *D. bouckaerti*, have a sense of the terms anterior and posterior that is the reverse of what is usually accepted in work on conodonts. It may be of some service to offer here a summary of current information on the genus, with Voges' (1959, pp. 275–277) observations rendered into English (see passages headed 'Translation') and with the terms anterior and posterior now taken as they are normally understood. Corrections of this kind, inserted by the translator (S.C.M.), are square bracketed in the translated sections.

The genus *Dollymae* (Hass 1959, p. 394) has the form of an inverted cup, whose upper (i.e. the oral) surface bears a blade-carina and two subsidiary carinae. The free blade is situated anteriorly. It extends in carina form along the cup-surface and may project, spike-like, at the posterior margin. The blade-carina is slightly curved and is regarded as being convex toward the outer side. The outer portion of the cup is wider than the inner. The blade-carina and the two antero-laterally directed subsidiary carinae diverge from the posterior part of the oral surface to give a clear impression of sagittate (arrow-like) form. A radial carina may be developed within the angle between the outer subsidiary carina and the blade. The broadly excavated aboral surface shows its maximum vertical dimension at a point which lies near the posterior end and which corresponds with the point of convergence of the carinae on the oral surface.

Four distinct forms of *Dollymae* have been recognized. They are:

1. *Dollymae sagittula* Hass (Hass 1959, p. 394; pl. 47, figs. 7, 10):

*Description.* Sagittate, slightly asymmetrical unit. Near-straight blade is free anteriorly and bears denticles that are either erect or posteriorly directed. Blade-denticles fuse with one another along the oral surface of the cup to give a narrow earina. Relatively large terminal denticle of earina projects at posterior end. Two subsidiary carinae, the outer slightly curved, the inner almost straight, each bearing a single row of fused denticles. Crest line of denticles is highest near mid-length of each subsidiary earina and becomes lower near confluence with posterior part of blade-earina, whose distinctly large terminal denticle is of the same character as denticles on subsidiary earinae. Oral surface of cup smooth in areas away from earinae. Excavated aboral side bears grooves corresponding to courses of the oral surface's carinae.

2. *Dollymae hassi* Voges 1959 (Pl. 33, figs. 5–10 of Voges 1959, holotype, Vo 59/4, shown there in figures 5, 6):

*Translation.*

*Diagnosis.* a species of the genus *Dollymae* with parapet-like or nodose-ridged subsidiary carinae and with a radial carina (on the outer side). The upper surface of the blade bears two rows of nodes. In adult specimens the [posterior] margin of the cup has strengthening in the style of the carinae.

*Description of the holotype.* The arcuate cup makes a right angle with the slightly bent blade as it crosses it. The outer portion of the cup is the larger. The subsidiary carinae on the crest of the cup are low and discontinuously developed in the holotype, and arise from a point situated slightly [in front of] the [posterior] end of the ridge-like blade. The angle between blade and subsidiary carina is acute on the inner side and almost reaches a right angle on the outer side. It is divided by the radial carina, whose upper margin is nodose.

The cup has a concave [anterior] margin on the inner side. The outer [anterior] margin is divided into two embayed parts by the projecting free termination of the radial carina. The lateral margins of the cup are restricted, the [posterior] margin broadly rounded. Near the free terminations of the subsidiary carinae the [posterior] margin is strengthened by a wavy parapet. Short ridges reach [forward] from this parapet to bring about an almost complete ornamentation of the oral surface of the cup.

The nodes developed in two rows along the oral surface of the blade are arranged in pairs with linking low ridges. On the cup the nodes fuse, forming a ridge which reaches a short way beyond the point of origin of the two subsidiary carinae but which fails to reach the thickened [posterior] margin of the cup.

The conodont is broadly excavated aborally. Greatest depth is found below the [posterior] termination of the blade. The courses of the two subsidiary carinae, the radial carina and the blade are indicated by grooves which originate from the point of greatest depth. Toward the [anterior] end of the blade the sides of the excavation converge to produce narrower, trench-like form.

*Juvenile specimens.* Here again the aligned nodes on the oral surface of the blade are paired and fuse in the [posterior] part of their course to give a ridge. The subsidiary carinae, the radial carina and (if present) the parapet-like thickening at the [posterior] margin of the cup are made up of simple transverse ridges or discontinuous series of nodes. The angle between subsidiary carina and blade is acute on the inner side and approximately right on the outer. The outline and the excavation of the aboral surface are essentially as given for the holotype.

*Relationships.* The deep excavation of the aboral side, the grooves below the subsidiary carinae and blade and the crudely arcuate arrangement of the subsidiary carinae at the [posterior] end of the blade are characteristic of the genus *Dollymae*. In this species the spike at the [posterior] end of the blade is stunted. The arrow-like shape and the difference in ornament separate *D. sagittula* from *D. hassi*. The forms *Dollymae* sp. A and *Dollymae* sp. B are distinct chiefly by their lack of a radial carina.

*Dollymae* was probably derived from *Scaliognathus*.

### 3. *Dollymae* sp. A (Plate 33, figs. 11–14 of Voges 1959).

*Translation.*

*Description.* The cup has an arcuate [posterior] margin and slightly concave to convex inner and outer [anterior] margins. The outer portion of the cup is the larger. The two subsidiary carinae lie in a curve which is sited close to the [posterior] margin of the cup. They originate from a point slightly [in front of] the [posterior] end of the ridged blade. The carinae are simple, ridge-like, or (in large specimens) have nodes and transverse ridges.

The oral edge of the blade always bears a row of denticles. These are fused with one another almost to their free terminations, where they can be seen to be of circular or oval cross-section. Set lower, on either side of the oral edge of the free blade, there are rows of irregular nodes. In one specimen they appear in simple ridged form, and in another (smaller) they are not yet developed. On the cup, the teeth of the oral edge of the blade are fused to produce a ridge which goes beyond the point of origin of the subsidiary carinae and projects at the [posterior] margin in the form of a spike.

The aboral surface of the conodont is excavated and the course of the blade and of the subsidiary carinae are indicated by grooves whose courses converge at the deepest point of the aboral surface, situated below a point near the [posterior] end of the ridged blade. The free blade may be grooved, or merely slit, along its length.



*Relationships.* To *Dollymae hassi*, see under that species. The arrow-like shape agrees with that of *Dollymae sagittula*, but the upper surface ornaments are not at all comparable. For the distinction from *Dollymae* sp. B, see below, under 'Description'.

4. *Dollymae* sp. B. (pl. 33, figs. 15–17 of Voges 1959), now referred to *D. bouckaerti* by Groessens (1971, p. 14, pl. 1, figs. 6–8).

*Translation.*

*Description.* This form shows strong resemblance to *Dollymae* sp. A, but the free blade carries only one row of denticles and the subsidiary carinae have a middle position on the cup. These carinae, in large specimens, are made up of nodes and transverse ridges. They arise near the [posterior] end of the ridged blade but not necessarily both from the same point. The angle between subsidiary carina and blade is obtuse to right on the outer side and right to acute on the inner. The curved blade, which in its free part bears a row of fused teeth, goes over into ridged form on the cup and extends spike-like beyond the [posterior] margin of the cup.

The small number of specimens available does not provide for a definitive statement on the form of the cup, but there does seem to be a tendency toward relative narrowness of the two lateral portions of the cup. A middle line drawn through these would run oblique to the blade.

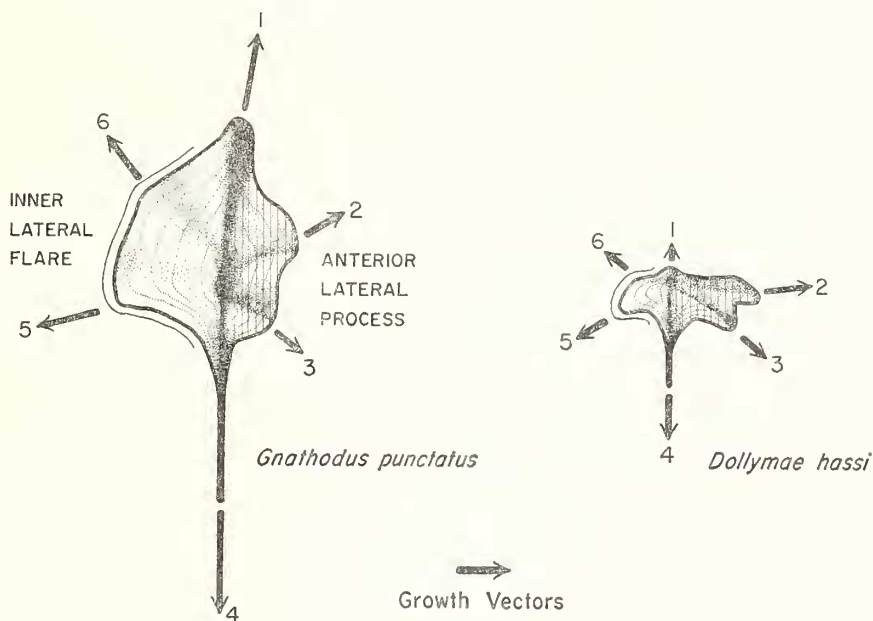
The aboral surface of the conodont is excavated. The deepest point is found where the transverse depressions running below the subsidiary carinae meet the groove coming from the aboral margin of the blade. The free blade is cut by a slit along part of its length only.

*Relationships.* To *Dollymae hassi* see above. For the distinction from *Dollymae sagittula*, the statements made under *Dollymae* sp. A would apply again.

Groessens, as noted above, has referred *Dollymae* sp. B to his new species *D. bouckaerti*. But his description of the new species supplies less detail than Voges offered for *Dollymae* sp. B, so it is still worthwhile to refer to the Voges observations. One finds, for example, that Groessens (1971, p. 14) makes no mention of the siting of the subsidiary carinae (Voges specified a medial position on the lateral extensions of the cup), nor does he make the point that these carinae need not originate both from exactly the same point on the axis of the conodont. On the other hand, Groessens has noted distal bifurcation of the subsidiary carinae, and Voges made no mention of any such feature. The two descriptions clash in what they specify for the form of the blade: bent according to Voges, straight according to Groessens. Groessens's illustration of the holotype of *D. bouckaerti* does indicate a resemblance to Voges's *Dollymae* sp. B, but his diagnosis and description are less precise than one would wish. Since Groessens and Voges have different views on the stratigraphic level (relative to the first appearance of *Scaliognathus anchoralis*) at which their representatives of *Dollymae* emerge it is particularly important that the degree of resemblance of *Dollymae* sp. B and *Dollymae bouckaerti*, complete or otherwise, should be clearly documented.

The literature carries occasional comments on relationships between *Dollymae* and other forms of conodont. Hass (1959, p. 394) noted a superficial resemblance to *Ancyrodella*. Voges (1959, p. 276) briefly remarked that *Dollymae* was probably derived from *Scaliognathus*. Lindström (1970) tentatively referred *Dollymae* to his family Bactrognathidae, thus associating it with *Bactrognathus*, *Doliognathus*, *Scaliognathus* and *Staurogathus*. An interesting observation made by Groessens (1971) is that immature stages of his *D. bouckaerti* can be distinguished from his *Spathognathus bultyncki* only by the presence of nodes on the oral lateral surfaces of the cup. Groessens's suggestion would link *Dollymae* to forms whose basal excavation is relatively large and open, rather than to forms with more restricted basal features, such as *Scaliognathus*.

The Chillaton conodonts suggest another possible relationship. *Dollymae hassi* and *Gnathodus punctatus* may be compared in terms of the features of their aboral surfaces. The two surfaces have the same general scheme of topography, but the gnathodid has a relatively well developed posteriorward groove and *Dollymae hassi* is relatively well developed along laterally directed axes. One axis, directed antero-laterally, represents the course of the radial carina. The suggestion could be rendered in the terms Lindström (1964) used to describe the *Prioniodus* plan, referring to what are here called 'axes' as the



TEXT-FIG. 1. Six major growth vectors identified in *Gnathodus punctatus* (drawn from BU 22088/21, cf. Pl. 110, fig. 13) and in *Dollymae hassi* (drawn from BU 22090/3, cf. Pl. 109, fig. 1). Anterior lateral process and inner lateral flare identified in *G. punctatus* as suggested by Lindström (1964). Note that the inner lateral flare appears on what is by normal convention the outer side of the conodont. Anterior lateral processes (vertical lines) and inner lateral flares (extra outer contour) indicated following the scheme of ornamentation used by Lindström (1964, fig. 33).

branchings of what Lindström called the inner lateral flare and the anterior lateral process. Text-figure 1 attempts to identify these features in the two forms.

It should be said that there is more than their common adherence to the *Prioniodus* plan to suggest a relationship linking *G. punctatus* and *D. hassi*. There is some stratigraphic evidence that the two might be in some way associated (note the present case, in which *G. punctatus* is the most common gnathodid, and also Voges' faunas 30 and 32 in which relative abundance of *G. punctatus* coincides with relative, if much less impressive, abundance of *D. hassi*), and there is a clear resemblance to be seen between details of ornament found here in *G. punctatus* (nodes, and less common short ridges) and details found in the first group of variants of *D. hassi* described below.

Groessens (1971) has suggested that his *Dollymae bouckaerti* might have been derived from a spathognathodid. The suggestion here is that *Dollymae hassi* might have been



derived from a gnathodid. It should not be thought that these are two conflicting views on the origin of the 'genus' *Dollymae*. Both might be valid. If both are valid, this, in turn, need not be taken to mean that the 'genus' *Dollymae* is diphyletic. In the systematic section below, the discussion of *G. punctatus* points to the possibility of yet another independent production of *Dollymae*. The source would appear to be again *G. punctatus*, but this time a *G. punctatus* in which the postero-laterally directed radial feature of oral surface ornament (arranged along the number 6 vector shown in text-figure 1) is relatively well developed. The associated *Dollymae* would be in this case the 'species' *D. sagittula*, whose aboral character (see Hass 1959, p. 47, fig. 7) seems to resemble that of the local variety (i.e. number 6 vector prominent) of *G. punctatus* (see Hass 1959, pl. 47, fig. 18). If the resemblance is a genuine one, it would seem to follow that in *D. sagittula* the 'inner lateral flare' is relatively well developed, whereas in *D. hassi* growth seems to have favoured the 'anterior lateral process'.

These are proposals which should be checked when a greater abundance of *Dollymae* material is available. It will be necessary to consider both 'left' and 'right' forms (shown by Hass 1959, pl. 47—note that his fig. 10 and fig. 7 refer to two different specimens—by Voges 1959, pl. 33 and here on Plate 109) and to discover whether accelerated development of an anterior lateral process, as opposed to an inner lateral flare, might even involve departures from total mirror-image symmetry in left and right forms.

*Dollymae hassi* Voges 1959

Plate 109, figs. 1-4, 6-10, 12; text-fig. 1

v\*1959 *Dollymae hassi* Voges, pp. 275-276, pl. 33, figs. 5-10

*Material.* BU 22088/1, 19, 22, 26, 27; BU 22089/1; BU 22090/3, 8, 30 (all figured). BU 22088/17, 20; BU 22090/5, 22, 23, 24, 46 (not figured).

*Remarks.* It is convenient to refer to a number of variants seen here:

1. Some forms have discrete, rather punctate ornament found on the posterior part of the oral surface of the cup. The crestal features of the subsidiary carinae are more continuously developed. The terminal (i.e. most posteriorly situated) single node of the main carina is relatively large (e.g. Pl. 109, fig. 4). These are the specimens which may be compared with *Gnathodus punctatus* as discussed above.

2. Certain other specimens, whose cup is more widely extended in the lateral sense, show ridge-like development in all of the crestal features of the oral surface, especially in the crest situated near the posterior margin. The ridge-like development may involve lateral mergings of the elements of a more punctate scheme of ornament. The angle

EXPLANATION OF PLATE 109

Revultex pulls dusted with ammonium chloride. All  $\times 30$ .

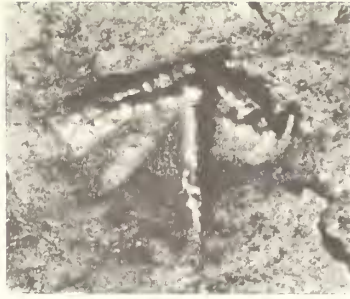
Figs. 1-4, 6-10, 12. *Dollymae hassi* Voges. 1, 4 (BU 22090/3, BU 22088/1) are aboral and oral views of one conodont. 8, 9 (BU 22088/27, BU 22090/30) are aboral and oral views of one conodont. 2, BU 22088/22. 3, BU 22090/8. 6, BU 22088/26. 7, BU 22089/1. 10, BU 22088/19. 12, BU 22088/17.

Figs. 5, 13. *Gnathodus punctatus* (Cooper). 5 (BU 22090/25) inner lateral view. 12 (BU 22090/27) oral view.

Fig. 11. *Spathognathodus* cf. *stabilis* (Branson and Mehl). BU 22090/10.



1



2



3



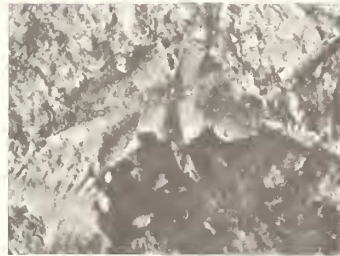
4



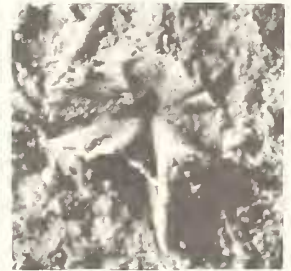
5



6



8



10



7



9



11



12



13





between radial carina and outer subsidiary carina is here smaller than that between radial carina and main carina (Pl. 109, fig. 9).

3. Certain forms show a closer approach to bilateral symmetry (but clearly do not achieve this). The outer subsidiary carina may follow a slightly curved (convex-posteriorward) course. Ornament is relatively delicate here and elements of the low crest situated near the posterior margin become discrete, ridge-like, and fade as they run towards the crests of the subsidiary carinae (Pl. 109, fig. 3).

4. One small specimen shows near-continuous development of the posteriorly situated ridge and the carinal crests (Pl. 109, fig. 12).

All of these have radial carinae, and should therefore be referred to *D. hassi* rather than to any other described species of the genus. The same conclusion is suggested by their lack of any conspicuous, spike-like posterior projection, although group 1 forms do show a local slight bulging of the posterior margin, and in group 3 the fine ridge situated near the posterior margin migrates toward that margin (and may possibly override it) in the neighbourhood of the length-axis of the conodont. The most robust form found here (Pl. 109, fig. 2) is one that does not easily fall into any of the four informal groupings suggested above. Features of both group 1 (conspicuous single node) and of group 3 (posterior ridge migration toward posterior margin in neighbourhood of length-axis) can be seen; possibly a better understanding of interrelationships between these different groups (accounting for ontogenetic variation perhaps) might dispose of this apparent anomaly. None of the specimens in the Chillaton fauna shows the yet more robust ornament found in the holotype.

#### Genus GNATHODUS Pander 1855

##### *Gnathodus delicatus* Branson and Mehl 1938

Plate 110, figs. 5, 7, 8, 9

- \*1938 *Gnathodus delicatus* Branson and Mehl; 145, pl. 34, figs. 25–27.
- 1963 *Gnathodus delicatus* Branson and Mehl; Ziegler, 327, pl. 2, figs. 5, 7, 9, 12, 14 (?figs. 8, 13 = *G. punctatus*).
- 1965 *Gnathodus delicatus* Branson and Mehl; Budinger, 56–57, pl. 2, figs. 9–13.
- 1968 *Gnathodus delicatus* Branson and Mehl; Canis, 74, fig. 7 only (fig. 8 = *G. punctatus*?).
- v1969 *Gnathodus delicatus* Branson and Mehl; Rhodes, Austin and Druce, 97–98, pl. 30, figs. 6a–c only (non pl. 18, figs. 12a–d = *G. punctatus*).
- v1969 *Gnathodus delicatus* Branson and Mehl; Matthews (1969a), 267, pl. 46, fig. 4 (with synonymy).
- v1969 *Gnathodus delicatus* Branson and Mehl; Matthews (1969b), pl. 51, fig. 7.
- 1969 *Gnathodus delicatus* Branson and Mehl; Rexroad, 18–19, pl. 4, fig. 1.
- 1970 *Gnathodus delicatus* Branson and Mehl; Marks and Wensink, 261–262, pl. 3, figs. 8, 9, 11.
- 1970 *Gnathodus delicatus* Branson and Mehl; Thompson and Fellows, 85, pl. 1, figs. 14, 17, 18 only (non pl. 2, figs. 1–5 = *G. punctatus*).

*Figured specimens.* BU 22088/27; BU 22090/28, 47, 49.

*Remarks.* In *G. delicatus* the parapet found alongside the carina on the inner oral surface of the cup runs from a point near the posterior end and becomes slightly broader in a short anteriorly situated segment of its length. The broader outer oral surface bears a line of nodes beside a long posteriorly situated segment of the carina's course. The remainder of the outer oral surface may carry further nodes. These specifications are

met by the majority of the forms referred to *G. delicatus* here (see examples in Pl. 110, figs. 5, 7), but one individual deserves special comment. The specimen (Pl. 110, fig. 9) is relatively slim and carries its parapet and outer line of nodes high on either side of the carina. It seems to bear some resemblance to *G. cuneiformis*. Ziegler (1963, pl. 2, figs. 5, 12) has figured specimens which are transitional between *G. delicatus* and *G. cuneiformis*; but the present individual shows a clear broadening of its inner parapet at a point situated near the anterior end, and this is taken to suggest an affinity with *G. delicatus*. Meischner (1971, fig. 2: '*G. cf. cuneiformis*') has sketched a somewhat similar case, and has suggested it to be related to *G. punctatus* and *G. delicatus*. The relationship between *G. delicatus* and *G. punctatus* is evident in the specimens figured on plate 2 of Ziegler (1963). Marks and Wensink (1970) have noted transitions from *G. delicatus* to *G. cuneiformis* and from *G. delicatus* to *G. punctatus* in their Spanish material. See below for further observations on the *G. delicatus*-*G. punctatus* transition. Matthews (1969*a*) suggested that Thompson's (1967) *G. sp. cf. G. bilineatus* might be referred to *G. delicatus*. The suggestion could be made again for *G. sp. cf. G. bilineatus* as figured by Thompson and Fellows (1970), and might apply also to the *G. cf. G. bilineatus* mentioned in Thompson, Ford and Sweet (1971, 707).

### *Gnathodus punctatus* (Cooper 1939)

Plate 109, figs. 5, 13; Plate 110, figs. 1-4, 11-15; text-fig. 1

- \*1939 *Drypheuotus puuctatus* Cooper, 386, pl. 41, figs. 42, 43; pl. 42, figs. 10, 11.
- 1959 *Gnathodus puuctatus* (Cooper); Hass, 395, pl. 47, 11-18 (?also *G. delicatus*, pl. 48, fig. 4 only).
- ?1963 *Gnathodus delicatus* Branson and Mehl; Ziegler, pl. 2, figs. 8, 13 only.
- 1965 *Guathodus punctatus* (Cooper); Budinger, 58-59 (with synonymy).
- 1967 *Guathodus puuctatus* (Cooper); Thompson, 40-41, pl. 5, figs. 12-15.
- ?1967 *Guathodus* n. sp. B Thompson; 43, pl. 4, figs. 1-4.
- 1968 *Gnathodus puuctatus* (Cooper); Canis, 538, pl. 74, fig. 21.
- v?1969 *Guathodus puuctatus* (Cooper); Rhodes, Austin and Druce, 105-106, pl. 18, figs. 1a-c, 10a-11d.
- v. 1969 *Guathodus delicatus* Branson and Mehl; Rhodes, Austin and Druce, pl. 18, figs. 12a-b only (pl. 30, figs. 6a-c = *G. delicatus*).
- v. 1969 *Guathodus bilineatus* (Roundy) transitional from *G. puuctatus* (Cooper); Rhodes, Austin and Druce, pl. 30, fig. 18.
- v1969 *Guathodus puuctatus* (Cooper); Matthews (1969*a*), 267-268; pl. 46, fig. 2.
- v1969 *Guathodus puuctatus* (Cooper); Matthews (1969*b*), pl. 51, fig. 12.
- 1970 *Guathodus cf. G. punctatus* (Cooper); Marks and Wensink, 263, pl. 3, fig. 10.

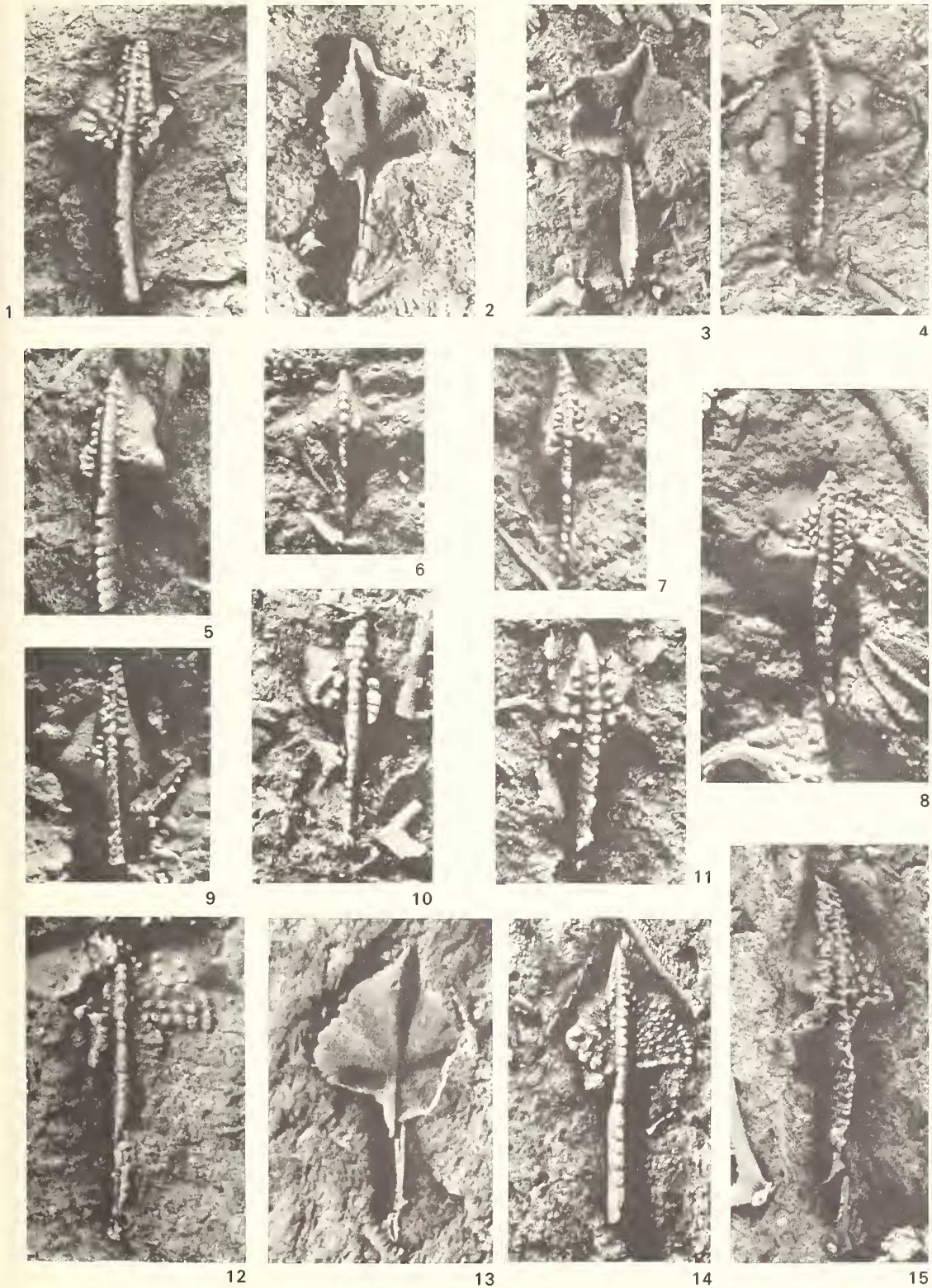
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#### EXPLANATION OF PLATE 110

Revultex pulls dusted with ammonium chloride. All  $\times 30$ .

Figs. 1-4, 11-15. *Gnathodus punctatus* (Cooper). 1, 2 (BU 22090/44, BU 22089/15) are oral and aboral views of one conodont. Similarly with 3, 4 (BU 22090/19 aboral and BU 22088/12 oral) and 13, 14 (BU 22088/21 aboral and BU 22090/13 oral). 11, BU 22090/21. 12, BU 22088/23. 15, BU 22088/6. Figs. 5, 7, 8, 9. *Gnathodus delicatus* Branson and Mehl. 5, BU 22088/27. 7, BU 22090/49. 8, BU 22090/28. 9, BU 22090/47. Fig. 6. *Guathodus* sp. juv. BU 22088/2. Fig. 10. *Guathodus semiglaber* Bischoff. BU 22090/20.





MATTHEWS, SADLER and SELWOOD, Carboniferous conodonts





1970 *Gnathodus punctatus* (Cooper); Thompson and Fellows, 86–87, pl. 1, figs. 15, 16, 19; pl. 2, figs. 14–17.

.1970 *Gnathodus delicatus* Branson and Mehl; Thompson and Fellows, pl. 2, figs. 1, 5 only (pl. 1, figs. 14, 17, 18 = *G. delicatus*).

*Figured specimens.* BU 22088/6, 12, 21; BU 22089/15; BU 22090/13, 19, 21, 25, 27, 44.

*Remarks.* A wide range of form is referred to *G. punctatus* here. Particular variants are:

1. Forms transitional to *G. delicatus*: note especially the specimen figured on Pl. 109, fig. 13, which has all of the characters specified above for *G. delicatus* (with each individual feature now more robustly developed) plus here a rudimentary, curved (convex toward the carina) inner parapet.

2. Relatively small forms which do not have the distinctively curved inner parapet of *G. punctatus* but which do have more than one row of nodes on that side (Pl. 110, fig. 11): Voges (1959, p. 284) referred specimens of this kind to *G. punctatus* and Matthews (1969a, pl. 46, fig. 2) followed suit. Two further cases recorded in the literature might deserve the same interpretation. They are *Gnathodus* n. sp. B of Thompson (1967)—but note that Thompson and Fellows (1970, pp. 90–91, pl. 3, figs. 11, 15) would now refer a rather wider range of form, including some relatively poorly ornamented individuals, to *G. sp. B*—and *Gnathodus* cf. *G. punctatus* of Marks and Wensink (1970). Marks and Wensink suggest that their forms resemble those of Rhodes, Austin and Druce and also one figured by Ziegler (1963, pl. 2, fig. 4). Neither suggestion seems particularly apt. A comparison with Ziegler (1963, pl. 2, figs. 8, 13) would be better.

3. Forms which have well developed ornament closely adjacent to the posterior part of the carina on either side (Pl. 110, figs. 1, 2, 15). Ziegler's (1963, pl. 2, fig. 4) specimen might be better compared with these. This ornament does not merge with the carina and this provides a means of distinguishing these forms from *G. semiglaber* even where the curved inner parapet is not conspicuously well developed. The specimen figured on Pl. 110, fig. 15 is of this kind. So, too, perhaps is Burton's (1964, table) *G. bilineatus*, which Thompson and Fellows (1970, p. 87) would refer to *G. semiglaber*. *G. semiglaber* of Canis (1968, pl. 74, fig. 5) is again vaguely of this character.

4. A single specimen which shows much stronger resemblance to *G. semiglaber* is illustrated on Pl. 110, figs. 3, 4. The form of the cup, and its relatively poorly ornamented upper surface, would clearly suggest *G. semiglaber*; but the growth of the outer side shows (Pl. 110, fig. 3) a radial effect strongly developed towards the posterolateral angle, and the posterior part of the carina has nothing of the thickening commonly found in *G. semiglaber*. The specimen is not greatly different from one referred to *G. semiglaber* by Thompson and Fellows (1970, pl. 2, figs. 7–10).

5. Specimens unequivocally referable to *G. punctatus* have on their inner oral side a short curved parapet which is convex toward the carina and on their outer oral side a broad noded surface. Only one of the present specimens (Pl. 110, fig. 12) has a parapet set clearly apart from the carina in the manner seen in some of the specimens figured by Hass (1959: e.g. his pl. 47, figs. 14, 15, 17). In the present material one more commonly finds the condition shown in Hass's (1959), pl. 47, fig. 16, where nodes other than those of the parapet are present on the inner oral surface. There is a further difference between *G. punctatus* as figured by Hass and *G. punctatus* as found here: Hass's specimens show a clear radial (along a line bisecting the angle between the carina and the anterior margin of the outer side of the cup) effect in the ornament of the outer oral surface of the

cup. No such effect is evident in the Chillaton specimens, although a similarly directed effect is plainly seen in the growth-lines of the aboral surfaces. It was suggested above that the Chappel Limestone form of *G. punctatus*, with this strong radial element, may be associated with the *D. sagittula* mode of *Dollymae*, and the Chillaton form, lacking that feature, linked instead with the *D. hassi* mode. It is interesting to observe that Voges (1959, p. 284) has noted the absence of the radial feature of outer oral surface ornamentation from his specimens of *G. punctatus*. He found *G. punctatus* to be especially common in his faunas 30 and 32, both of which have produced *D. hassi*.

*Gnathodus semiglaber* Bischoff 1957

Plate 110, fig. 10

- v\*1957 *Gnathodus bilineatus semiglaber* Bischoff, 22, pl. 3, figs. 1-10, 12-14 (8-10, 12-14 are juveniles according to Bischoff).
- v1959 *Gnathodus semiglaber* (Bischoff); Voges, 284, pl. 33, figs. 38, 39.
- 1964 *Gnathodus semiglaber* (Bischoff); Rexroad and Scott, 30, pl. 2, figs. 1, 2.
- 1965 *Gnathodus semiglaber* Bischoff; Budinger, 59-60, pl. 1, figs. 14-20; pl. 3, figs. 1, 4-6. (with synonymy).
- 1967 *Gnathodus semiglaber* (Bischoff); Thompson, 41, pl. 4, figs. 11-14.
- 1967 *Gnathodus semiglaber* (Bischoff); van Adrichem Boogaert, 179-180, pl. 2, fig. 20 only.
- 1968 *Gnathodus semiglaber* (Bischoff); Canis, 538, pl. 74, fig. 19 only (fig. 5 = *G. punctatus*?).
- v non 1969 *Gnathodus semiglaber* Bischoff; Rhodes, Austin, and Druce, 106-107, pl. 30, fig. 1 (= *G. delicatus*?)
- v?1969 *Gnathodus antetexanus* Rexroad and Scott; Rhodes, Austin, and Druce, 93-94, pl. 18, figs. 13a-d only.
- 1970 *Gnathodus semiglaber* Bischoff; Marks and Wensink, 264, pl. 3, figs. 19, 20.
- 1970 *Gnathodus semiglaber* Bischoff; Thompson and Fellows, 87, pl. 2, figs. 2-4, 7, 10.

*Material.* BU 22090/20 (figured).

*Remarks.* The discussion of *G. punctatus* (above) shows that the difference between *G. punctatus* and *G. semiglaber* is not clear cut (see, especially, group 3 and 4 there). Rhodes, Austin and Druce (1969, pl. 30, figs. 2, 8) have figured forms which they regard as transitional between *G. punctatus* and *G. semiglaber*. However, the specimen shown in their figure 8 appears to have more in common with the gnathodids attributed to *G. typicus* by Thompson (pl. 4, figs. 5, 7, 8, 10) and later transferred to *G. antetexanus* by Thompson and Fellows (1970). The single Chillaton specimen referred to *G. semiglaber* shows some resemblance to *G. punctatus* in the character of its outer platform, but has a posterior carina of a kind more common in *G. semiglaber*. Its inner oral surface, although much narrower than is typical of *G. semiglaber*, carries a very brief parapet of a kind that suggests the character of *G. semiglaber* and not at all that of *G. punctatus*. This brief parapet shows some resemblance to the relatively widely developed anterior part of the parapet seen in specimens referred here to *G. delicatus*.

Some recent authors (e.g. Rhodes, Austin, and Druce 1969; Thompson and Fellows 1970) have followed Rexroad and Scott (1964) in attributing Mehl and Thomas's (1947) specimen of *G. perplexus* to *G. semiglaber*. A specimen of that character (see Mehl and Thomas 1947, pl. 1, fig. 4) would be identified as *G. delicatus* here (see also Rexroad 1969, synonymy list on p. 18).



## Genus POLYGNATHUS Hinde 1879

*Polygnathus communis* Branson and Mehl 1934

*Remarks.* The nominate subspecies is known to range from the Famennian (*styriacus*-Zone according to Ziegler 1962, 1971; or even earlier according to recent American information in Klapper *et al.* 1971; see also van Adrichem Boogaert 1967) into the Dinantian. It is abundant in the Chillaton fauna. So, too, is the subspecies *P. communis carina* (treated below). A single small polygnathid (Pl. 3, fig. 12) has the general form of *P. communis* but is distinct in having a line of nodes arranged parallel to the carina on either side of the platform. Hass (1959, pl. 49, fig. 11) has figured a specimen of *P. communis* which is relatively well provided with nodose ornament, although there the nodes run wider on either side to affect the form of the platform margins. Druce's (1969) *P. communis dentatus* may be of similar character, with the nodose effect confined to the anterior parts of the platform.

*Polygnathus communis carina* Hass 1959

Plate 111, figs. 6, 7, 13

- \*1959 *Polygnathus communis* var. *carina* Hass, 391, pl. 47, figs. 8, 9.
- v1959 *Polygnathus communis carina* Hass; Voges, 289, pl. 34, figs. 5, 6.
- .1963 *Polygnathus communis* Branson and Mehl; Ziegler, pl. 1, figs. 5, 6 only.
- .1964 *Polygnathus communis carina* Hass; Rexroad and Scott, 34, pl. 2, figs. 24, 25.
- .1965 *Polygnathus communis* Branson and Mehl; Budinger, pl. 1, figs. 12, 13 only.
- .1967 *Polygnathus communis carina* Hass; Thompson, 45, pl. 2, figs. 2, 10; pl. 4, figs. 6, 9.
- .1968 *Polygnathus communis carina* Hass; van Adrichem Boogaert, 184, pl. 2, figs. 43a, b.
- .1968 *Polygnathus communis carina* Hass; Canis, 544, pl. 72, figs. 18–20.
- .1968 *Polygnathus communis* var. *carina* Hass; Manzoni, 666–667, pl. 62, figs. 2, 3.
- .1969 *Polygnathus communis carinus* Hass; Druce, 95, pl. 18, figs. 12a–c.
- .1970 *Polygnathus communis carinus* Hass; Thompson and Fellows, 92–93, pl. 3, fig. 14.

*Figured specimens.* BU 22088/11, 25; BU 22090/14, 18, 45.

*Nomenclatural note.* Species-group names in the form of adjectives in the nominative singular are required to agree in gender with the generic name with which they are combined (ICZN Article 30). The sub-species name *carina*, however, is a noun in the nominative singular (ICZN Article 11 g i 2), and is therefore not subject to any such requirement.

*Remarks.* The present material shows all transitions between *P. communis communis* and *P. communis carina* (compare remarks in Voges 1959, pp. 289–290). Voges encountered *P. communis carina* in significant numbers in his faunas 30 and 32. In the Chillaton fauna the carinate ornament at the anterior end of the platform appears to consist, on the inner side, of fine transverse ridges (up to 3 in number) rather than a transverse arrangement of nodes. Hass (1959, pl. 47, fig. 8) has illustrated a comparable case. It can further be observed in the present material that the basal cavity is situated at the blade-platform junction in smaller specimens but lies enveloped in the platform growth of more mature specimens, at which stage it appears to be of relatively small size. Budinger (1965) has made similar observations for *P. communis*. Druce's (1969, p. 94) suggestion, that in the *P. communis* group the basal cavity is at the blade-platform junction, is inexact. Cooper's (1939) pre-Welden shale conodonts may include

*P. communis carina* (see, for example, Cooper's 1939, pl. 39, figs. 1, 2, 9, 10, 23, 24, 33–36, all of which were referred to *P. communis communis* by Rexroad and Scott 1964).

Genus PSEUDOPOLYGNATHUS Branson and Mehl 1934

*Pseudopolygnathus triangulus* Voges subsp. indet.

Plate 111, figs. 14–18

*Figured specimens.* BU 22088/9; BU 22089/8, 13; BU 22090/11, 32.

*Remarks.* A number of the pseudopolygnathids encountered in conodont faunas of approximately this age have platforms broader anteriorly than those of *Ps. multi-striatus* but less broad and less straight at their anterior margins than is common in *Ps. triangulus pinnatus*. Also, they lack the pinnate development of the inner anterolateral margin characteristic of the latter form (Voges 1959). Pseudopolygnathids of this apparently intermediate kind are seen in Hass (1959: '*Pseudopolygnathus asymmetrica* Cooper') and in Thompson and Fellows (1970: '*Pseudopolygnathus triangulus pinnatus* Voges'). Thompson and Fellows's specimens, like the one figured by Thompson in 1967, pl. 4, figs. 17, 18 (note the more satisfactorily pinnate character here) are relatively small and have relatively large basal cavities. A larger specimen figured by Rexroad and Scott (1964, pl. 2, fig. 28: '*Pseudopolygnathus triangula*') shows a fair degree of resemblance to one form (Pl. 111, fig. 15) encountered here. Ziegler (1963, p. 324, pl. 1, fig. 1) has figured a specimen—'*Pseudopolygnathus triangula* subsp. indet. (wahrscheinlich *pinnata*)'—which has finer ribs than are seen in Rexroad and Scott's or any of the present specimens, and which may be closer than either of these to *Ps. triangulus pinnatus*. Ziegler's specimen and two of the Chillaton forms (Pl. 3, figs. 14, 18) have each a relatively restricted basal cavity of the kind seen in *Ps. triangulus pinnatus*.

Genus SIPHONODELLA Branson and Mehl 1944

*Siphonodella crenulata* (Cooper 1939)

Plate 111, figs. 1, 11

\*1939 *Siphonognathus crenulata* Cooper, 409, pl. 41, figs. 1, 2.

1966 *Siphonodella crenulata* (Cooper); Klapper, 18, pl. 3, figs. 5–8 (with synonymy).

EXPLANATION OF PLATE 111

Revultex pulls dusted with ammonium chloride. All  $\times 30$ .

Figs. 1, 11. *Siphonodella crenulata* (Cooper). 1, BU 22091/2. 11, BU 22088/13.

Figs. 2, 3. *Siphonodella* cf. *crenulata* (Cooper). Oral (BU 22090/42) and aboral (BU 22089/3) views of one conodont.

Figs. 4, 5. *Siphonodella obsoleta* Hass. Aboral (BU 22088/5) and oral (BU 22090/1) views of one conodont.

Fig. 10. *Siphonodella* cf. *obsoleta* Hass. BU 22090/31.

Figs. 6, 7, 13. *Polygnathus communis carina* Hass. 6, 7 oral (BU 22088/11) and aboral (BU 22090/14) views of one conodont. 13, BU 22090/45.

Figs. 8, 9. *Polygnathus communis* subsp. Oral (BU 22088/25) and aboral (BU 22090/18) views of one conodont.

Fig. 12. *Polygnathus communis* subsp. BU 22088/4. Note nodes on oral surface.

Figs. 14–18. *Pseudopolygnathus triangulus* Voges subsp. indet. 14, 15 aboral (BU 22090/11) and oral (BU 22088/9) views of one conodont. Similarly with 17 (BU 22090/32, oral) and 18 (BU 22089/8, aboral). 16, BU 22089/13.